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(54) METHOD OF DRILLING HORIZONTAL BORES THROUGH EARTH FORMATIONS

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Abstract of the Disclosure

An improved method is described for drilling horizontal bores through earth formations. The method includes the steps of forming a horizontal pilot hole through the entire earth formation to be bored and placing a segmented drill rod within the pilot hole with the ends of the rod extending at least to the ends of the pilot hole. An auger is then connected to one end of the rod with the opposite end being connected to a power means for pushing and pulling the rod and auger. The auger is then pulled toward the power means into the earth formation while rotating to cut an enlarged bore, after which it is pushed without rotation to excavate earth cuttings formed.

BACKGROUND OF THE INVENTION

Field of the Invention

This invention relates to an improved method for drilling horizontal bores through earth formations.

In particular, the invention relates to the drilling of a bore or tunnel extending horizontally through earth formations over relatively long distances, for instance, in the installation of gas, water or other service conduits that are installed underground.

Description of the Prior Art

There are a variety of devices available for forming relatively small diameter bores or tunnels horizontally over relatively short distances, but these devices have quite severe restrictions when the distance to be bored extends to greater distances, such as 25 feet or more. One of the most commonly used devices for small diameters and short distances is a rotating auger. The main disadvantage of the auger systems used to date have been that they require relatively large operating pits to hold the apparatus required to rotate the auger and also to provide working space for the operators and to remove the soil augered by the device.

Another type of device used for forming horizontal bores is the push- or pull-type cutter such as that described in Merrick, U.S. Patent 2,664,273. However, the Merrick device can be used only over relatively short distances due to the excessive power required to move a core of earth over any substantial distance. This is because of the great frictional resistance between the core and the surrounding earth walls. A system which attempts to overcome these disadvantages is shown in Atkins et al U.S. Patent 3,469,638.

That system forms a pilot hole by means of a push-type forming head mounted on the end of a drill rod with a series of hole compactors mounted on the rods and spaced from the pilot hole forming head. Once the compacted pilot hole has been formed, a cutter device is pulled through the pilot hole to cut a segmented plug of soil which must then be forced out of the tunnel formed. Once again, very large amounts of power are required in order to pull the plug from the tunnel formed.

The present invention takes advantage of the most desirable features of both the rotating augers and the push- or pull-type cutters while at the same time avoiding the main disadvantages of these.

SUMMARY OF THE INVENTION

Thus, in accordance with the present invention, a horizontal bore is drilled through an earth formation by first forming a horizontal pilot hole through the entire earth formation to be bored. Within this hole is positioned a segmented drill rod with the ends of the rod extending at least to the ends of the hole. An auger is connected to one end of the rod while the other end is connected to a power means for pushing and pulling the rod and auger. The auger is then pulled toward the power means into the earth formation while rotating to cut an enlarged bore. Then the auger is pushed in a direction away from the power means to excavate the earth cutting formed at the end of the bore remote from the power means.

For drilling a long bore, the segmented drill rod is progressively shortened from the power means end to progressively cut the enlarged bore. Then to clear the cuttings

out of the enlarged bore, the drill rod is progressively lengthened from the power means end using the auger, preferably fixed against rotation, as a pushing head to push the cuttings out of the end of the enlarged bore remote from the power means.

Depending on the nature of the soil being drilled, the auger can be used in association with a compactor to compact the walls of the tunnel and prevent collapse.

There are a number of advantages to the method of this invention over both the auger methods and the push-pull methods of the prior art. The advantages over the previous auger methods are readily evident in that a long horizontal hole can be bored using only a short auger section. By forming the pilot hole through the entire earth formation to be drilled, and then connecting this short auger section to the end of the rod remote from the power source, the drilling is commenced from the remote end and all of the cuttings are ejected from the remote end. This entirely avoids the usual problem of trying to dispose of the cuttings from a pit containing the power source. It will also be evident that it is much less expensive to use a segmented drill rod with a short auger section and to utilize the push-pull feature for ejecting the cuttings.

As for the advantages over push-pull systems such as that described by Atkins et al, it will be seen that with the auger system of this invention only a single pass of the device is required even for drilling a quite large hole. This can be compared with the Atkins et al system where a series of progressively larger cutters are used to progressively enlarge the hole when a large hole is required.

The step of pushing the cuttings out of the drilled tunnel need not be carried out after every auger length of tunnel has been cut and practical experience with different types of soil can easily determine the amounts of cuttings that can be pushed out of the tunnel by the auger at one time.

Also, depending on the pitch of the auger and the nature of the soil, the auger may be allowed to rotate freely while being pulled toward the power source for tunnel cutting or it may be powered for rotation by a motor. During the pushing stage for ejecting cuttings it is preferable to lock the auger against rotation.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

A preferred embodiment of the invention is illustrated by the attached drawings. It is to be understood that the drawings and the following description thereof are intended for the purposes of illustration only and are not to be construed as defining the invention claimed. In the drawings:

Figure 1 is a schematic view of the invention showing a pilot hole being formed;

Figure 2 is a sectional elevation showing an auger being attached;

Figure 3 is a sectional elevation showing the auger boring;

Figure 4 is a sectional elevation showing a bored section being cleared;

Figure 5 is a sectional elevation showing a further stage in the tunnel formation;

Figure 6 is an isometric view of an additional cutter tool; and

Figure 7 is an isometric view of a depth adjusting guide shoe.

As illustrated in the drawings, a pair of pits or shafts 10 and 11 are dug down into the earth in preparation for drilling a horizontal bore between the two pits. In this particular illustration the pit 10 is the power source pit while pit 11 is the cuttings or soil receiving pit.

Mounted within pit 10 is a power unit 12 having a heavy frame 13 with a pair of top flanges or tracks 14. A drive unit 15 is mounted for travel back and forth on tracks 14 by means of support wheels 16. The back and forth motion of the drive unit 15 is controlled by means of hydraulic cylinder 17.

The drive unit 15 includes an hydraulic motor 18 with a control unit 19. Power is supplied to the hydraulic motor via flexible lines 20 connected to an hydraulic pump 21.

The hydraulic motor includes gripping jaws 39 for receiving and gripping a segmented drill rod 22. The segments of the drill rod are connected by means of screw connectors 23.

In order to drill a horizontal bore through an earth formation between pits 10 and 11, the drive unit 15 is positioned as shown in Figure 1 and a length of drill rod is positioned in the jaws 39. Cylinder 17 is then actuated moving the drive unit 15 and drill rod forward, pushing the rod into the formation. At this location the jaws 39 are released and the drive unit returns to the position shown in Figure 1 where another length of drill rod is positioned in the jaws 39. At this stage the hydraulic motor can be activated to join the two lengths of rod by rotation of the screw connection 23 and the complete cycle is then repeated.

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This joining together and pushing of drill rod section is continued until the end of the first length of drill rod breaks through the earth into the pit 11.

At this point the auger 24 is connected to the end of the drill rod 22 within pit 11 as shown in Figure 2. Then, the drill rod and auger 24 are pulled toward pit 10 while being rotated by the hydraulic motor 18. This cuts a length of tunnel as shown in Figure 3 which is usually equal to the distance of movement of the drive unit 15. The drive unit can then be reversed, pushing the drill rod and auger in a direction away from the drive unit and clearing the cuttings from the drill tunnel as shown in Figure 4. If desired, the drive unit can be reciprocated back and forth several times along track 14 to compact the walls of the tunnel just formed. Then, with the unit in the position shown in Figure 3, the jaws 39 of the drive unit are released from the drill rod and the drive unit then advances and takes a fresh grip on the drill rod at its location of maximum forward advance. The drilling stage is then repeated to cut the next section of tunnel. As these drilling stages are carried out, the tunnel progresses from pit 11 to pit 10 and it will be seen from Figure 5 that as the distance between the drive unit 15 and the auger 24 decreases, the end of the drill rod 22 extends into the previously drilled section 25.

Periodically as the tunnel is being cut, the auger may be pushed the entire distance along the already drilled tunnel to the position as shown in Figure 4 so as to completely clear cuttings from the tunnel. The frequency at which it is necessary to clear the tunnel in this fashion is determined largely by the nature of the soil being drilled. Particularly when there is an adjacent tunnel 25 into which the drill rod

can tr[illegible], this technique for drilling a horizontal tunnel proceeds very quickly since a skilled operator can very quickly carry out a series of grips and pushes on the drill rod to clear the already drilled tunnel. Of course, when there is not an adjacent tunnel 25, the drilling proceeds somewhat more slowly since it becomes necessary to connect and disconnect drill rod sections within pit 10 to travel the distance between the pits 10 and 11.

When the auger has worked its way through the entire earth formation to pit 10, it is then pushed back through the entire tunnel to the position shown in Figure 4 to completely clear the tunnel of cuttings and compact surfaces. The aguer can then be removed at pit 11 for the completion of the horizontal bore or tunnel. The drill rod is left within the tunnel and the drive unit 12 is lifted out pit 10 and moved up to pit 11 which then becomes the new drive unit pit for boring the tunnel in the next section.

Figure 6 shows a modification of the device with a cylindrical cutting tool 26 mounted on the drill rod in advance of the auger 24. With this arrangement, the cylindrical cutting tool serves to cut and compact the surfaces of a tunnel while being pulled into the earth formation and the adjacent auger then serves to break down the plug of earth that is cut by the cutting tool and remove this from the tunnel without a very heavy frictional drag which is inherent with any system which attempts to pull out an intact plug of earth. In other words, the device shown in Figure 6 combines the best of the previously known features with the feature of the present invention.

Another useful addition to the device of the invention is shown in Figure 7. Thus, it will be seen that if

changes in soil conditions, the presence of small rocks, etc. causes the tunnel direction to be somewhat out of alignment, the auger 24 can be used in association with a support member 27 and adjustable guide shoe 28 which can be used as illustrated to cause the auger to enlarge portions of the tunnel to correct errors of alignment.

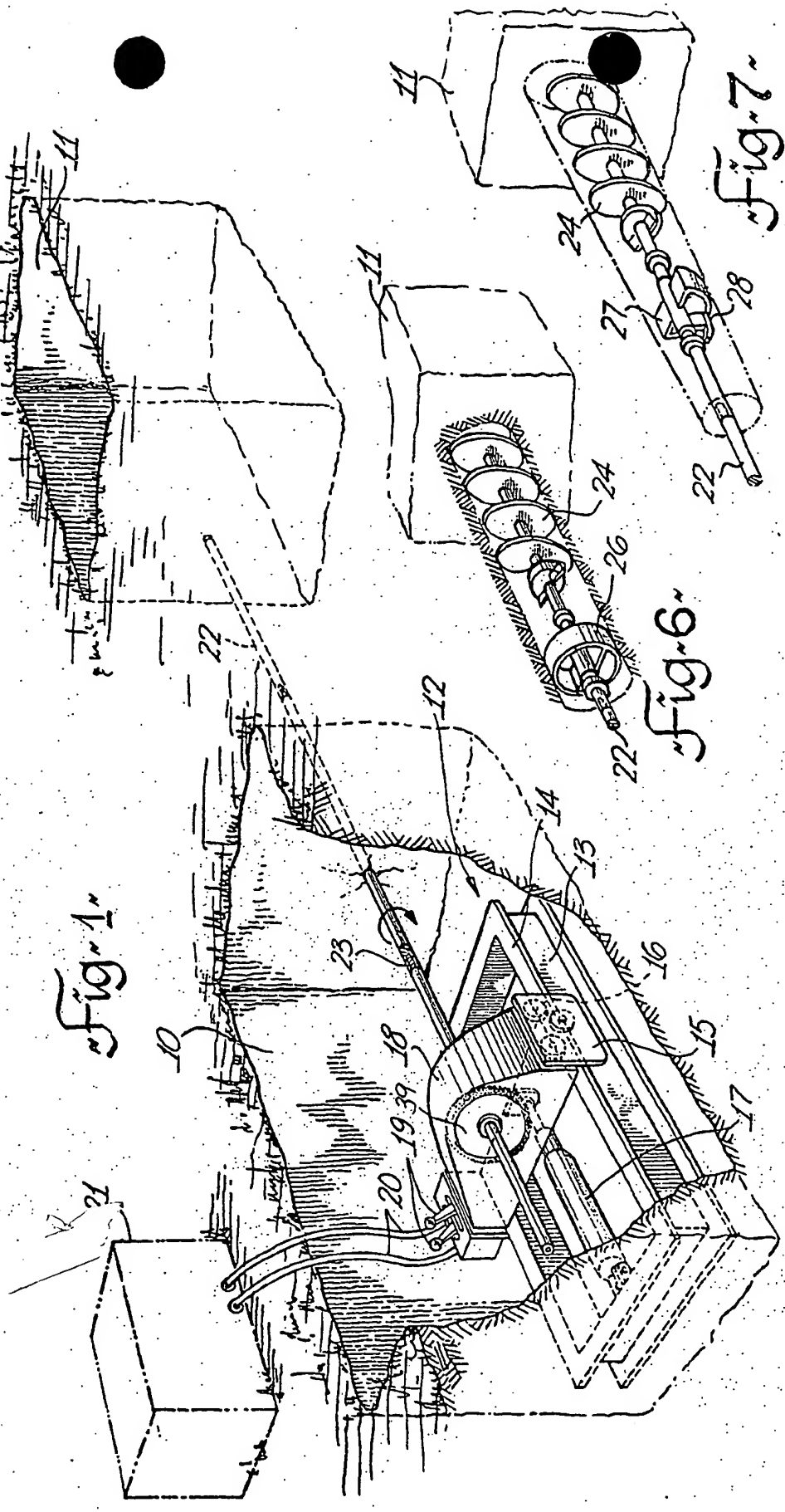
I Claim As My Invention:

1. A method of drilling a horizontal bore through an earth formation, comprising the steps of forming a horizontal pilot hole through the entire earth formation to be bored, placing a segmented drill rod within said pilot hole with the ends of the rod extending at least to the ends of the hole, connecting an auger to one end of said rod, the other end of said rod being connected to a power means for pushing and pulling said rod and auger, pulling said auger toward said power means into said earth formation while rotating to cut an enlarged bore and then pushing the auger to excavate earth cuttings formed.

2. A method according to claim 1 wherein the rod is progressively shortened from the power means end to progressively cut the enlarged bore and is lengthened from the power means end to push the cuttings out the end of the enlarged bore remote from the power means.

3. A method according to claim 1 wherein the auger is locked against rotation during the pushing action.

4. A method according to claim 1 wherein the auger is rotated by means of a motor driving the rod while being pulled toward the power means.



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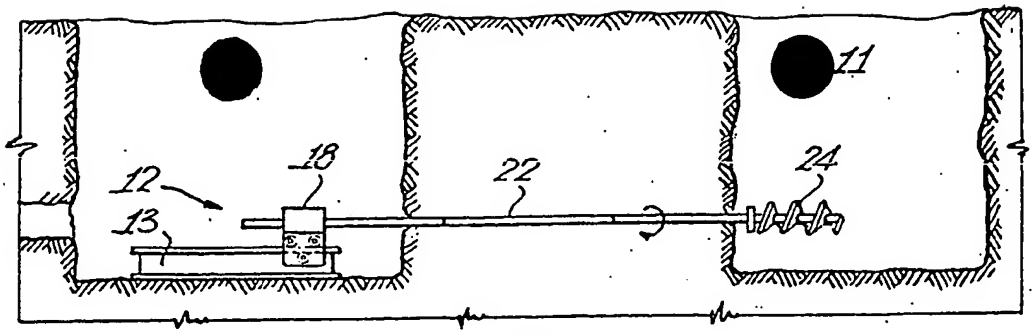
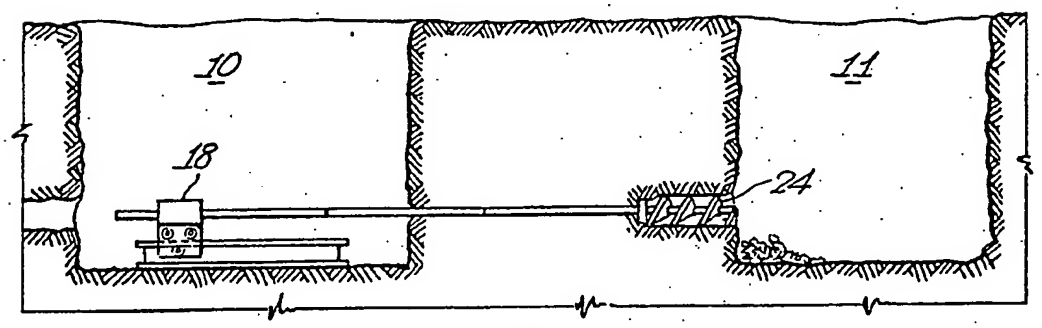
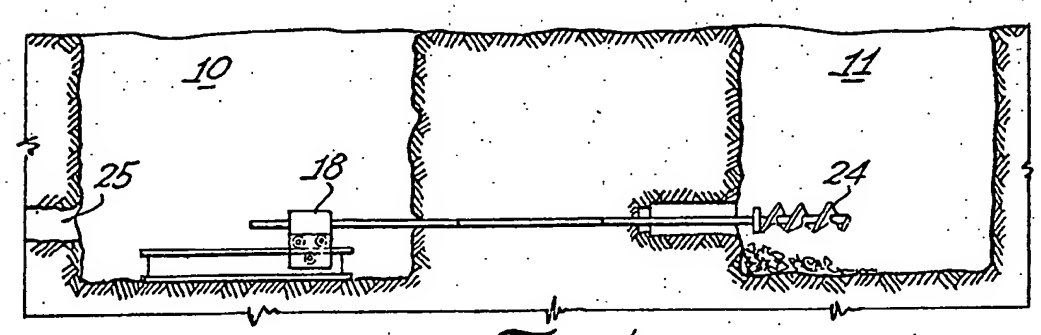


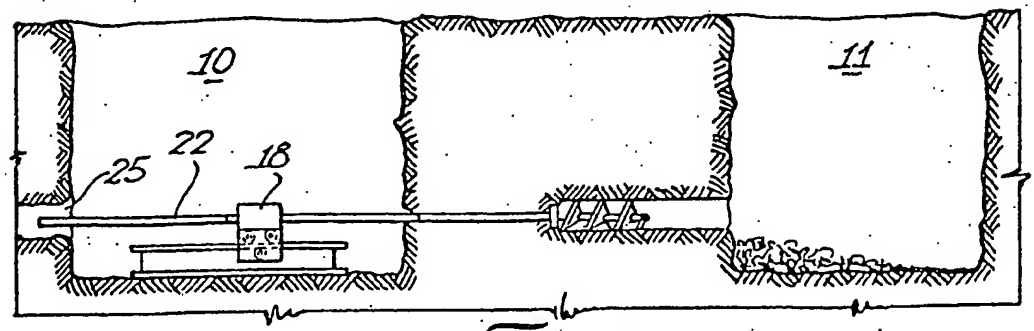
~Fig~2~



~Fig~3~



~Fig~4~



~Fig~5~

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